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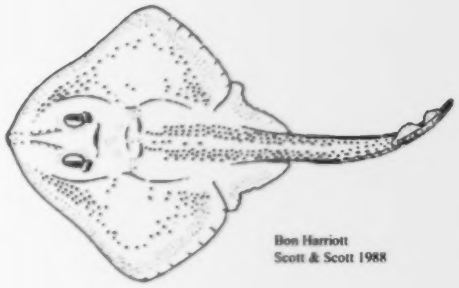
Science | Sciences
Gulf Region
Canadian Science Advisory Secretariat
Science Advisory Report 2005/063

RECOVERY POTENTIAL ASSESSMENT FOR WINTER SKATE IN THE SOUTHERN GULF OF ST. LAWRENCE (NAFO DIVISION 4T)



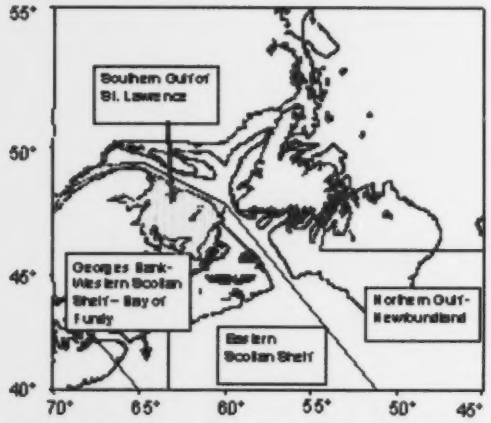


Figure 1: The four Designatable Units of winter skate.

Context

In 2005, winter skate (Leucoraja ocellata) in the southern Gulf of St. Lawrence were designated as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). They are currently being considered for listing on Schedule 1 of the Species at Risk Act. Winter skate mature at a much smaller size in the southern Gulf than in other areas. Thus, the southern Gulf population is considered to be a distinct Designatable Unit (DU). Based on catch rates in the annual research vessel (RV) survey of the southern Gulf, the abundance of mature individuals in this DU has declined by 98% since 1971, and is now at a historically low level. Elasmobranchs such as skates possess life history characteristics such as low fecundity and late age at maturity which increase their vulnerability to exploitation. COSEWIC suggested that the probable cause of the decline of winter skate in the southern Gulf is an unsustainable rate of capture as bycatch in fisheries directed at other groundfish species.

SUMMARY

- Winter skate in the southern Gulf of St. Lawrence are designated as endangered by COSEWIC and are being considered for listing on Schedule 1 of Canada's Species-at-Risk Act.
- Catch rates of adult winter skate in the DFO annual research survey have declined steadily since the early 1980s and are currently at the lowest level on record. Catch rates of juveniles increased in the survey from the early 1970s to the mid 1980s but have since also declined to low levels.
- Catch rates of winter skate in the DFO Northumberland Strait survey (conducted since 2000) declined by over 50% between 2001 and 2004.

Canada

- There is no directed fishery for winter skate in the southern Gulf. Estimated bycatch in fisheries for groundfish and shrimp declined throughout the 1970s and early 1980s, and has been very low (<50 t) since the early 1990s. Bycatch of winter skate in the scallop fishery is likely but its magnitude is unknown.
- A population model was used to estimate trends in mortality. The estimated exploitation rate declined steadily from the early 1970s to very low levels by the early 1990s. Natural mortality of juveniles appeared to be higher in the 1970s than in years since then. In contrast, natural mortality of adults appeared to increase in the 1980s and 1990s.
- The decline in winter skate abundance appears to be caused by this increase in adult natural mortality (or unknown human-induced mortality that is interpreted as natural mortality in the models).
- The increase in adult mortality occurred during a period of increasing grey seal abundance.
- Winter skate abundance is projected to continue to decline even with no bycatch in fisheries. Bycatch at the most recent level (10 t) has a negligible effect on the rate of decline but slightly higher bycatch (50 t) would substantially accelerate the decline.

BACKGROUND

Rationale for Assessment

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) considered the population of winter skate in the southern Gulf of St. Lawrence (NAFO Division 4T) to be a Designatable Unit (DU), based on its unique life history characteristics. In May 2005, COSEWIC designated this DU as endangered, and it is being considered for listing on Schedule 1 of Canada's Species at Risk Act (SARA). If listed, activities that would harm the species would be prohibited and a recovery plan would be required. Until such a plan is available, section 73(2) of SARA authorizes competent Ministers to permit otherwise prohibited activities affecting a listed wildlife species, any part of its critical habitat, or the residences of its individuals.

Under section 73(2) of SARA, authorizations may only be issued if:

(a) the activity is scientific research relating to the conservation of the species and conducted by qualified persons;
(b) the activity benefits the species or is required to enhance its chance of survival in the wild; or
(c) affecting the species is incidental to the carrying out of the activity.

Section 73(3) establishes that authorizations may be issued only if the competent minister is of the opinion that:

(a) all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted;
(b) all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals; and
(c) the activity will not jeopardize the survival or recovery of the species.

Decisions made on permitting of incidental harm and in support of recovery planning need to be informed by the impact of human activities on the species, alternatives and mitigation measures to these activities, and the potential for recovery. An evaluation framework, consisting of three phases (species status, scope for human–induced harm and mitigation) has been established by DFO to allow determination of whether or not SARA incidental harm permits can be issued. The analysis provided herein will inform decisions relating to the listing of winter skate and its

recovery planning. In the context of this status report, "harm" refers to all prohibitions as defined in SARA.

Species Biology

Winter skate (*Leucoraja ocellata*, Family Rajidae) are endemic to the Northwest Atlantic, occurring from Cape Hatteras to the northern Gulf of St. Lawrence and southern Newfoundland. Winter skate in the southern Gulf of St. Lawrence differ from winter skate on the Scotian Shelf and areas further south in size at maturity, maximum size, and in other morphological characters related to feeding (e.g., the number of tooth rows in the upper jaw, the shape of the upper jaw). Outside of the Gulf, winter skate are sympatric with a closely related species, the little skate *L. erinacea*. The differences between winter skate inside and outside of the Gulf may reflect character displacement between little and winter skate in areas of sympatry. In this case, the characteristics of winter skate in the Gulf are expected to be intermediate between those of little and winter skate elsewhere, or possibly similar to those of little skate (which it resembles in size at maturity).

Winter skate in the southern Gulf mature at a length of about 42 cm. This is much smaller than the length at maturity reported for winter skate elsewhere (75 cm). Age and growth data are not available for winter skate in the Gulf. Based on growth rates of little skate, which mature at about the same size as winter skate in the Gulf, a length at maturity of 42 cm would correspond to an age of 6 yr.

Winter skate are oviparous, depositing a single egg in a horny capsule or purse. The purse has adhesive mucus which helps to maintain bottom contact by attaching to substrate materials. Average annual fecundity has been reported to be 35 for winter skate outside the Gulf and 30 for little skate. Gestation time within the purses is estimated to be 18-22 months for winter skate in other areas and 6-9 months for little skate. Length at hatching from the purses is about 10-15 cm.

Predation by gastropods (which are able to bore holes through the leathery egg capsule) is thought to be the main source of mortality during the egg-capsule stage. Reported predators after hatching include sharks, other rays and grey seals.

In the southern Gulf of St. Lawrence, winter skate occur in shallow inshore areas in summer and move offshore in winter. Species residences are protected under SARA. However, winter skate do not have any known dwelling-place similar to a den or nest during any part of their life cycle, hence the concept of "residence" does not apply.

Fisheries

Reported landings of skates in the southern Gulf of St. Lawrence are low, exceeding 50 t in only four years between 1971 and 2002 and under 10 t in most years. Most of these landings are likely of thorny skate, with landings of winter skate negligible in the southern Gulf. However, winter skate are caught as bycatch in fisheries for other species and are discarded at sea. COSEWIC suggested that the probable cause of the decline of winter skate in the southern Gulf is an unsustainable rate of capture as bycatch in fisheries directed at other groundfish species.

ASSESSMENT/ANALYSIS

Winter skate in NAFO Division 4T occur primarily in the southern Gulf of St. Lawrence, where they occupy shallow inshore waters in summer and early fall. Winter skate also occur in the St. Lawrence Estuary in 4T, but appear to be very rare in this area. This analysis and the data presented in the COSEWIC status report focused on winter skate in the southern Gulf.

Stock Trends and Current Status

Trends in the relative abundance of winter skate were evaluated using data from an annual bottom-trawl survey, conducted in the southern Gulf each September since 1971. Uncalibrated vessel changes occurred in this survey in 2003 and 2004, though no changes in survey gear or protocol occurred in these years. Skates were grouped into two length classes: 1) 42 cm and longer, corresponding to the adult portion of the population, and (2) 21-41 cm, roughly corresponding to juveniles one year of age and older.

Juvenile catch rates fluctuated widely early in the time series, but tended to increase from the early 1970s to the mid 1980s (Figure 2). Juvenile catch rates declined beginning in the late 1980s, returning to the low levels observed in the early 1970s. Adult catch rates were relatively high early in the time series but declined steadily throughout the 1980s and early 1990s, and have been at a very low level since the mid 1990s (Figure 2).

A linear time trend is fit to the $\log_e$ catch rates of adults in Figure 3. The fitted line corresponds to a 96% decline over the 32-yr calibrated portion of the time series (1971-2002). The data in Figure 3 suggest that the decline in adult abundance may be on-going.

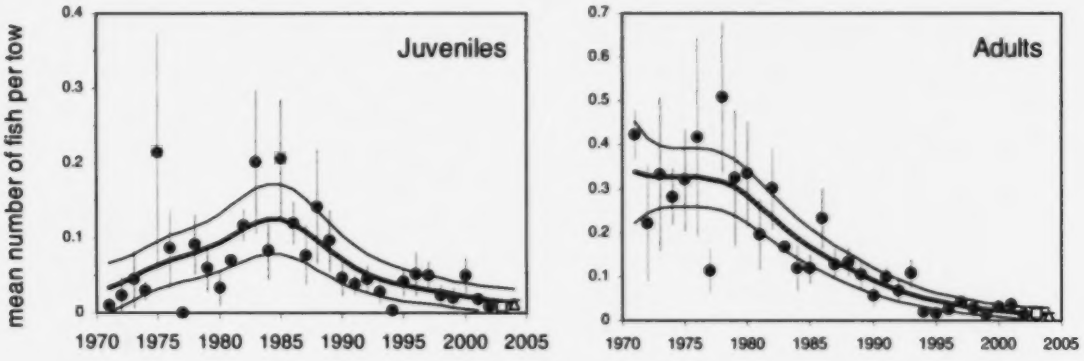


Figure 2. Catch rates (±1 standard error) of juvenile and adult winter skate in the September survey of the southern Gulf of St. Lawrence. Lines show a smoothed fit to the time trend with 95% confidence intervals.

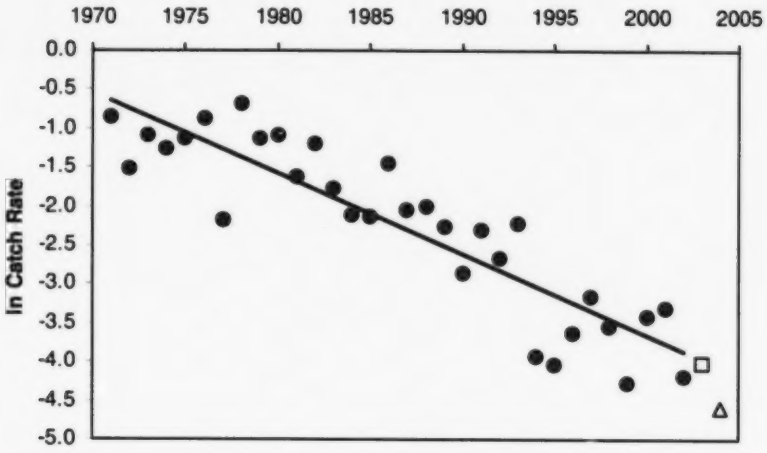


Figure 3. Log_e catch rates of adult winter skate in the September survey of the southern Gulf of St. Lawrence.

Winter skate tend to be caught in shallow inshore areas in September (Figure 4). About 60% of the population is estimated to occur outside of the survey area in inshore waters in September. If the geographic range of winter skate contracts as abundance declines, and the optimal habitat for winter skate occurs inshore of the survey area, then availability of winter skate to the survey may decrease as their abundance declines. In this case, changes in catch rates in the survey would over-estimate changes in population size.

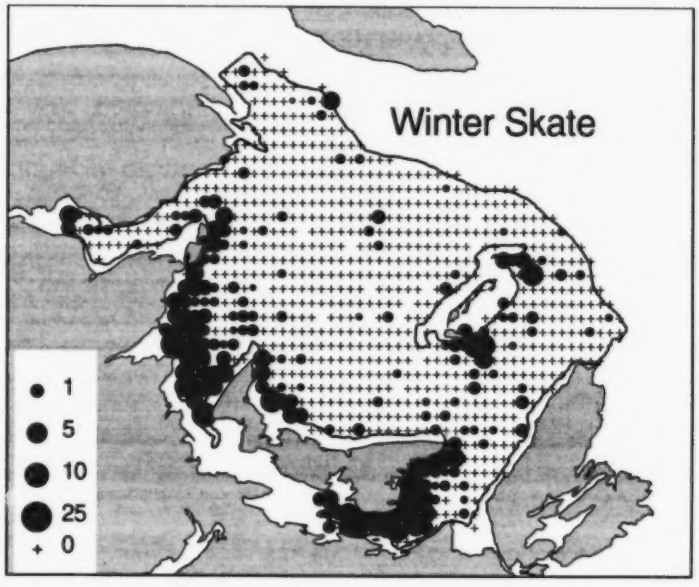


Figure 4. The distribution of winter skate catches (fish/tow) in the September survey of the southern Gulf of St. Lawrence, 1971-2002.

Information on winter skate abundance in the Northumberland Strait (including areas not covered by the September survey) is available from a bottom-trawl survey conducted between mid July and early August since 2000. This survey confirms that sharp declines in winter skate

abundance have also occurred in areas inshore of the September survey. Catch rates of winter skate declined by over 50% between 2001 and 2002 in this survey (Figure 5). Catch rates declined further in 2003 and 2004, again suggesting that the decline in abundance is on-going.

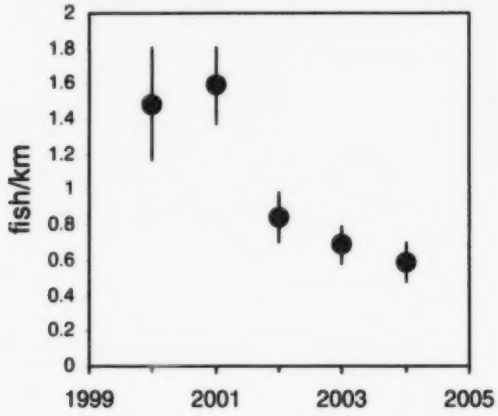


Figure 5. Mean catch rates of winter skate in strata 1-4 of the Northumberland Strait survey. Vertical lines are ±1 standard error.

A rough estimate of the abundance of winter skate in the southern Gulf can be made based on catch rates in the September survey given assumptions about catchability to the survey gear and the proportion of the population available within the survey area. Estimates differ depending on whether survey catch rates are adjusted to day or night catchability. Using the day-adjusted data, average adult abundance was estimated to be 5 million in the 1971-1975 period, declining to 360,000 in the 2000-2004 period. Using night-adjusted data, estimates were 22 million adults in 1971-1975, declining to under 2 million in 2000-2004.

Fishery Removals

Discarded bycatch of winter skate in fisheries for groundfish and shrimp was estimated using fishery observer data collected in 1991-2004. The proportion of winter skate in observed skate bycatch was estimated based on the proportion in research survey catches using a model that accounted for the effects of depth and season. Catch rates of winter skate relative to commercial species were estimated from the observed fishing trips. These were expanded to estimates of total bycatch based on the ratios of observed catch to total landings for the commercial species. Bycatch for years prior to 1991 was estimated based on the bycatch rates in 1991-1993 and the commercial landings in the earlier years, assuming that bycatch rates in the earlier years would depend on the relative abundance of winter skate and the commercial species. The abundance of winter skate relative to the commercial species in 1971-1990 was based on catch rates in the September survey.

Estimated winter skate bycatch was highest in 1971 at 2000 t (median estimate) and declined throughout the 1970s and early 1980s to about 500 t in the mid to late 1980s (Figure 6). Estimated bycatch declined sharply in the early 1990s, when fishing effort in the southern Gulf decreased with the closure of the cod fishery. The median estimate for bycatch was under 50 t in most years from 1993 to 2001, and 10 t or less since then. Bycatch of winter skate was mostly associated with catches of cod, American plaice, winter flounder and yellowtail flounder (Figure 7). Limited information suggests that the discard mortality rate for skates is greater than 50%.

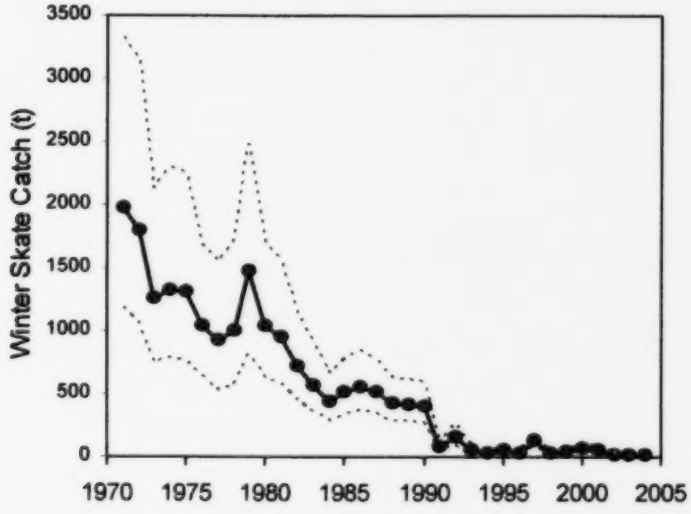


Figure 6. Discarded bycatch of winter skate in fisheries for groundfish and shrimp in the southern Gulf of St. Lawrence, 1971-2004. Lines show the median estimate with 90% confidence intervals.

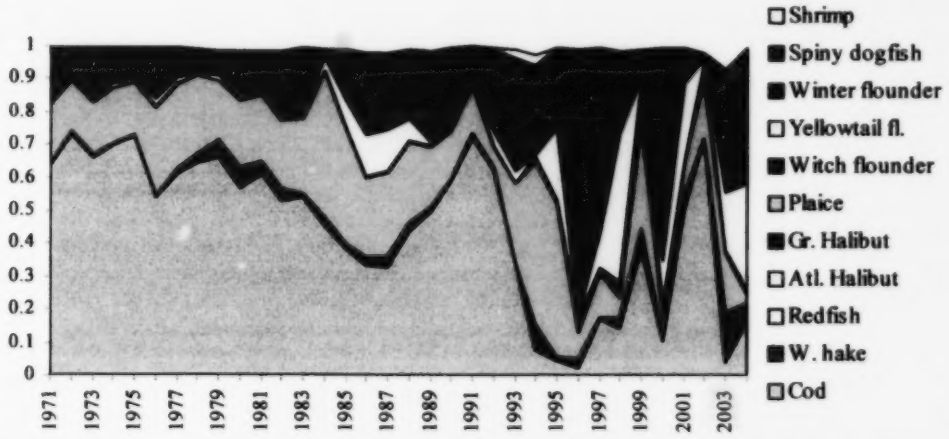


Figure 7. Proportion of winter skate bycatch associated with each of the commercially-important species, 1971-2004.

The scallop fishery in the southern Gulf is another potential source of winter skate bycatch. This fishery is conducted in summer in the shallow inshore waters occupied by winter skate at this time of year. Scallop landings rose sharply in the mid 1960s, peaked in the late 1960s and early 1970s, and declined rapidly in the early 1970s. Scallop dredging is an important source of skate bycatch in other areas (e.g., off New England) but its impact in the southern Gulf is unknown.

Mortality Trends and Possible Causes

Mortality trends and recovery potential were assessed using Bayesian state-space models. These models incorporate both observation error and the error associated with population dynamics processes (process error), and can incorporate prior information on these processes. Stage-structured population models were used because age-disaggregated data were not

available for this population. Two types of models were used. One type, referred to here as *Z* models, estimated trends in total mortality (*Z*) of juveniles and adults. Data inputs were catch rates in the September survey, treated as indices of relative abundance. The second type, referred to here as *M* models, estimated trends in natural mortality (*M*) and exploitation rate. Data inputs were the median estimates of discarded bycatch and the survey abundance indices. In this case, the survey indices were scaled to absolute abundance by correcting for catchability to the survey gear and availability within the survey area. Mortality of discarded skates was assumed to be 70%.

In the *Z* models, mortality was either constrained to be constant over the time series or was allowed to vary over time, either as decadal variation or as a trend over time. All models allowing temporal variation in mortality fit the survey indices substantially better than the model with constant mortality. The decadal model indicated that adult mortality was low in the 1970s and increased in the 1980s and 1990s, whereas juvenile mortality was high in the 1970s and lower in subsequent years (Figure 8). Results of the trend models were similar, indicating an increase in adult mortality and a decrease in juvenile mortality over time. The increase in adult mortality appeared to be roughly linear while the decline in juvenile mortality appeared to be non-linear, with juvenile Z declining early in the time series and then leveling off.

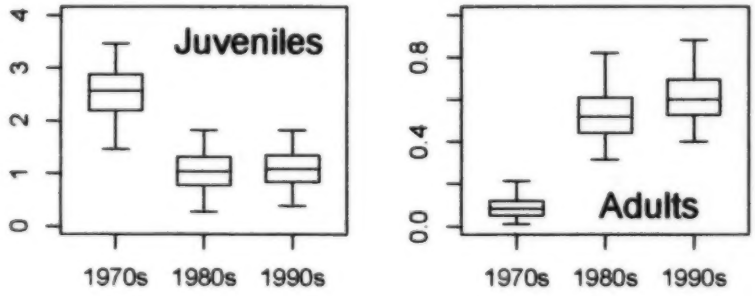


Figure 8. Estimated total mortality rate (Z) of juvenile and adult winter skate by decade. Vertical lines show the 95% credible limits, boxes the interquartile range and horizontal lines the median.

Based on the *M* models, the exploitation rate on adults was highest at the start of the time series and declined throughout the 1970s and early 1980s (Figure 9). Estimated exploitation rate was very low for adults after 1990 and for juveniles over the entire time series. For adults, the trend in exploitation rate was opposite to the trend in total mortality, indicating that the increase in adult mortality after the 1970s was due to an increase in natural mortality (or unknown human-induced mortality that is interpreted as natural mortality in the models). Estimated decadal variation in *M* was similar to the variation in *Z* except that the trend in adult *M* was stronger than the trend in *Z* (Figure 10), reflecting the opposing directions of trends in exploitation rate and *M* for adults.

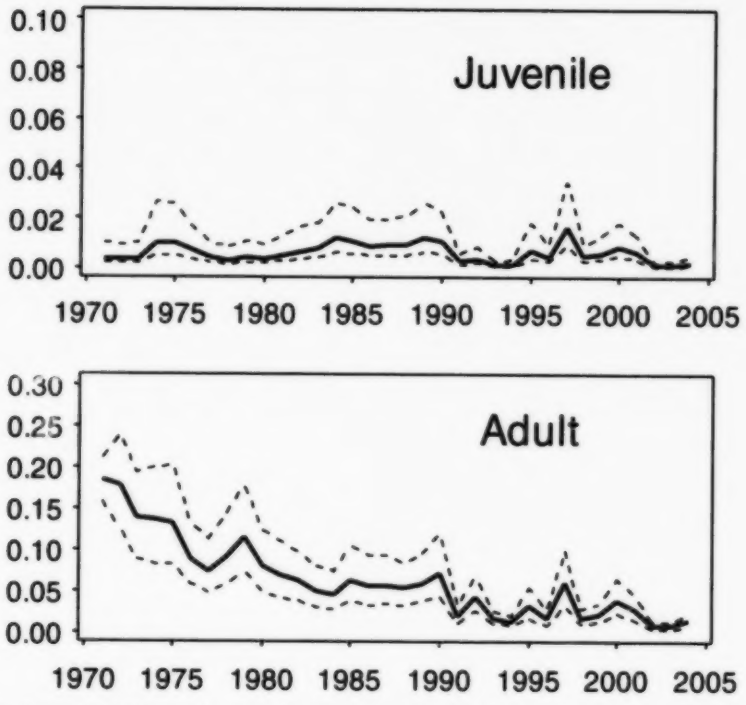


Figure 9. Estimated exploitation rate on juvenile and adult winter skate (median estimate and 95% credible limits).

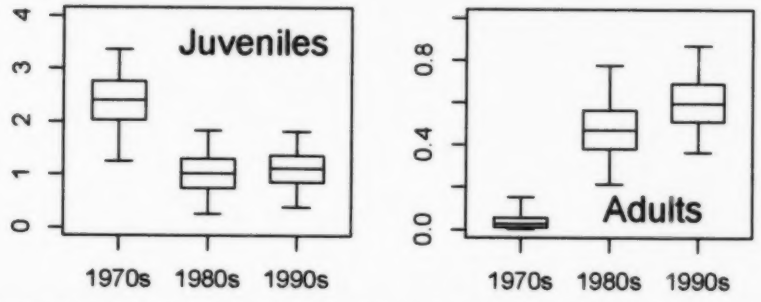


Figure 10. Estimated natural mortality rate (M) of juvenile and adult winter skate by decade. Vertical lines show the 95% credible limits, boxes the interquartile range and horizontal lines the median.

These trends in the natural mortality of winter skate may result from the dramatic changes in the southern Gulf ecosystem over the past 30 years. The abundance of grey seals, potential predators of skates, has been increasing in the southern Gulf since the 1970s. Cod are the dominant demersal fish in the southern Gulf. The abundance of large cod, potential predators of juvenile skates, declined sharply in the early to mid 1980s. Temperatures increased steadily over the 1971-2004 period in the shallow inshore waters occupied by winter skate during the summer growing season.

Possible causes of the trends in natural mortality were examined by modeling *M* as a function of potential explanatory variables (predator abundance and environmental conditions). Adult *M* showed a significant positive relationship with grey seal abundance (Figure 11), suggesting that

increased predation by seals may be a cause of the increased adult mortality. However, seal predation is thought to be focused on small fish, but juvenile *M* and seal abundance were not positively related. Possibly, any increased predation by seals on juvenile skate has been offset by reduced mortality from predation by large demersal fishes, which declined in abundance in the 1980s and 1990s. Models that included both large cod abundance and seal abundance as covariates of juvenile *M* did not support this suggestion, though such opposing effects may be difficult to detect through correlation analyses. Juvenile *M* showed a significant inverse relationship with inshore water temperature.

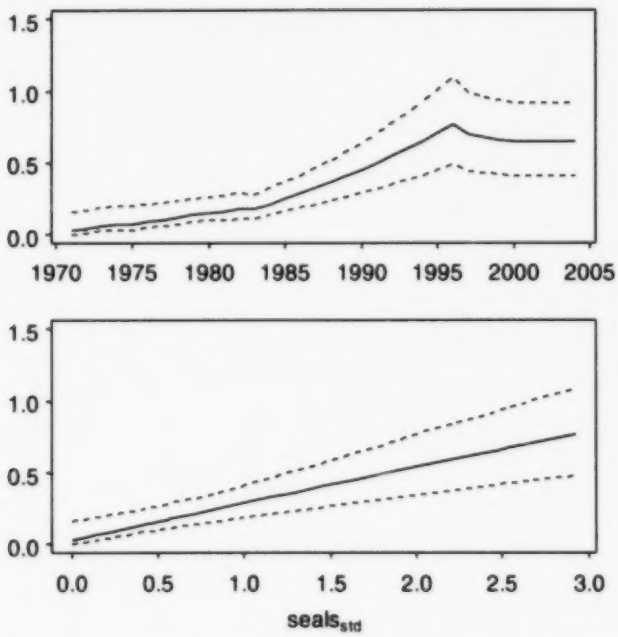


Figure 11. Natural mortality (M) of adult winter skate (median and 95% credible limits) predicted from the abundance of grey seals in the southern Gulf. Seal abundance standardized by subtracting the minimum and dividing by the standard deviation.

Recovery Targets

Recovery targets have not been established for winter skate. Potential recovery targets could be the survey catch rates observed in the 1970s or the long term mean. In terms of adults, these targets would correspond to survey catch rates 14 or 7 times the recent rates.

Recovery Potential

In order to evaluate recovery potential, winter skate abundance was projected 10 years into the future using the state-space models. Projections were based on the model with decadal variation in *M*. Future *M* was assumed to be at the 1990-2004 level. Future bycatch was assumed to be a) nil, b) at the 2002-2004 level (about 10 t), or c) at the 1993-2001 level (about 50 t). Based on these projections, the population is expected to steadily decline even in the absence of any bycatch in fisheries (Figure 12). Bycatch at the most recent (2002-2004) level has a negligible effect on the rate of decline. However, slightly higher bycatch, at the 1993-2001 level, sharply accelerates the expected rate of decline. The uncertainty around the projection is large but does not include recovery. No recovery of this population can be expected without a

decrease in adult natural mortality (or unknown human-induced mortality that is interpreted as natural mortality in the population models).

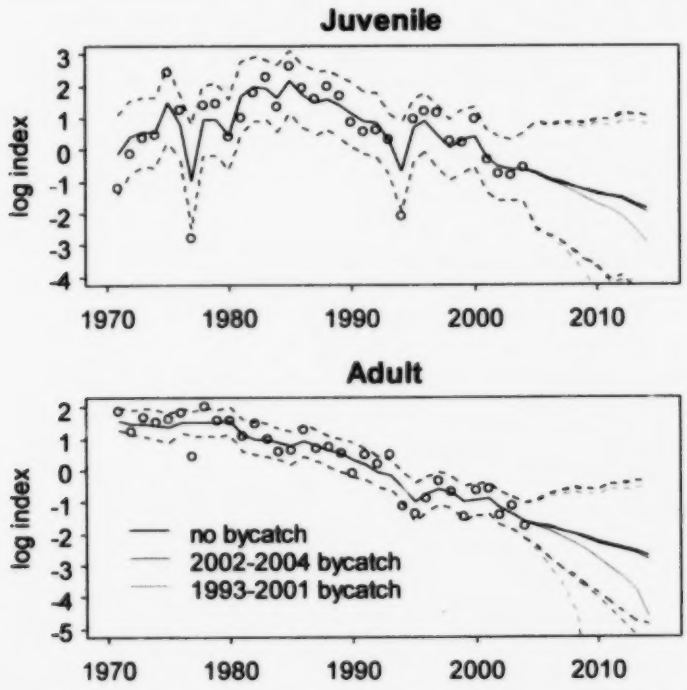


Figure 12. Projected population trajectories (median and 95% credible limits) given three bycatch scenarios.

Sources of Uncertainty

The population model includes a parameter θ giving the probability of maturing from a juvenile to an adult. The input data contained no information for estimating θ. The value for this parameter depends on growth and age at maturity. No growth model or information on age at maturity are available for this population. Published information for little skate, which matures at the same size as winter skate in the southern Gulf, was used to estimate a value for θ. The sensitivity of the model results to the value used for θ was examined. The estimated mortality rates depended on the value used for θ but trends in mortality were similar regardless of the value used.

There is no information on whether the growth rate of winter skate has changed over the 1971-2004 period (though size at maturity has not changed between the 1970s and the 2000s). The increase in juvenile abundance from the 1970s to the 1980s may reflect slower growth rather than increased survival of juveniles. In order to examine the sensitivity of results to the assumption that growth has not changed between 1971 and 2004, a change in growth was simulated by varying θ between decades. An extreme change was simulated, corresponding to a growth rate in the 1970s twice that in later years. These growth rates spanned the limits of plausibility in terms of years required to grow through the juvenile stage. This variation in θ had little effect on the estimates of juvenile mortality. It moderated the trends in adult mortality, but only slightly. Thus changes in growth alone cannot account for the trends in juvenile and adult abundance. These trends imply large changes in both juvenile and adult mortality.

The population dynamics of this stock are poorly understood. Juvenile abundance was very low relative to adult abundance in the 1960s and early 1970s. Subsequent increases in the ratio of juveniles to adults appear to indicate a five-fold increase in adult mortality.

The distribution of this stock is near the margins of the survey area. Trends in survey catch rates may be influenced by changes in the proportion of the stock within the survey area.

Possible impacts of increased predation by seals were apparent for adults but not for juveniles, even though predation by seals is thought to be focused on small fish.

The magnitude of winter skate bycatch in the scallop fishery is unknown. The survival rate of discarded catch is uncertain. Potential anthropogenic impacts on habitat have not been evaluated.

CONCLUSIONS AND ADVICE

The abundance of winter skate in the southern Gulf of St. Lawrence has declined sharply since the early 1980s and is currently at the lowest level on record. Based on research survey catch rates, adult abundance has declined by 96% over the 1971-2002 period.

There is no directed fishery for winter skate in the southern Gulf. The estimated exploitation rate on winter skate due to bycatch in fisheries for groundfish and shrimp declined through the 1970s and 1980s and is currently at a low level. Bycatch of winter skate in the scallop fishery is likely but its magnitude is unknown.

The decline in the abundance of winter skate appears to be caused by an increase in the natural mortality of adults (or unknown human-induced mortality that is interpreted as natural mortality in the population models). This increase in adult natural mortality occurred in the 1980s and 1990s when grey seal abundance also increased in the Gulf. Population models indicate a significant positive relationship between grey seal abundance and the natural mortality of adult winter skate. This suggests that the increased mortality of adult winter skate may be related to increased predation by grey seals.

Winter skate abundance is projected to continue to decrease over the next 10 years even if fishery bycatch is held to zero. No recovery of this population can be expected without a decrease in adult natural mortality (or unknown human-induced mortality that is interpreted as natural mortality in the population models). Bycatch at the most recent level (10 t) has a negligible effect on the rate of decline but slightly higher bycatch (50 t) would substantially accelerate the decline.

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